

The claimed invention is:

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- 5 1. A computer-readable medium having computer-executable instructions for performing a method of using expressions to establish a relationship between properties in code executable by a browser running on a computer, each property defining a characteristic of an object, the method comprising:
- declaring the value of a first property as a scalar value; and
- declaring the value of a second property as an expression, wherein the second property is a function of the first property.
- 10 2. The computer-readable medium of claim 1 having further computer executable instructions for: changing the value of the second property in response to a change in the value of the first property.
3. The computer-readable medium of claim 2 having further computer executable instructions for: automatically changing the value of the second property when the value of the first property changes.

4. The computer-readable medium of claim 2 wherein the computer-readable instructions are written in HTML code and define a document that forms a user interface, the computer-readable medium having further computer-executable instructions for: updating the document upon changing the value of the second property.

5. A computer-readable medium having stored thereon a data structure, the data structure including a plurality of nodes, comprising:

at least one leaf node stored in memory, each leaf node containing a scalar property;

at least one expression node stored in memory, each expression node containing an expression defining a dynamic property, the expression being a function of the scalar property;

at least one pointer stored in memory, each pointer mapping a dependent/dependency relationship between the scalar properties and the expressions, wherein upon notification of a change in the value for one of the scalar properties, a browser executes the expressions dependent on the scalar property having a changed value.

6. The computer-readable medium of claim 5 wherein:

the data structure is formed by a browser; and

the expression is written in a markup language.

7. The computer-readable medium of claim 6 wherein the markup language is HTML.

8. The computer-readable medium of claim 6 wherein two or more pointers map two or more scalar properties, respectively, to a single expression.

9. The computer-readable medium of claim 6 wherein two or more pointers map a single scalar properties to two or more expressions, respectively.

10. The computer-readable medium of claim 6 wherein two or more pointers map a single expression to two or more different expressions, respectively.

5 11. The computer-readable medium of claim 6 wherein at least one of the pointers maps a dependent/dependency relationship between two expressions.

12. The computer-readable medium of claim 6 wherein:

one of the pointers maps a dependent/dependency relationship between a scalar property and a first expression and another pointer maps a dependent/dependency relationship between the first expression and a second expression, the first expression forming a least-dependent expression and the second expression forming a most-dependent expression; and

the browser executes the expressions in the order of the least-dependent expression to the most-dependent expression.

13. The computer-readable medium of claim 12 wherein:

two pointers map the second expression to the first expression and a third expression, respectively, the second expression being dependent on the first and third expressions thereby being more dependent than the first and third expressions; and
the browser does not execute the second expression until the first and second expressions are executed.

14. A method of using expressions to establish a relationship between properties of a document generated by HTML code that is executable by a browser, the properties including constant properties and dynamic properties, the method comprising:

declaring a value of one or more scalar properties, wherein the value of the scalar

5 properties is not a function of another property;

creating one or more expressions, each expression declaring a value of a dynamic

property, each dynamic property being a function of another property; and

generating a dependency graph, the dependency graph having a plurality of nodes,

including at least one expression node and one leaf node, each expression

10 node corresponding to an expression and each leaf node corresponding to

a value of a scalar property, the dependency graph mapping the

relationship between the properties.

15. The method of claim 14 wherein the nodes have a dependent/dependency

relationship to one another and each node has either a dirty state or a clean state, the

15 method further comprising:

when the value for one of the properties changes, changing the state of the node

corresponding to the changed property to dirty;

propagating the dirty state to each of the nodes in the dependency graph that are

dependent on the node corresponding to the changed property; and

20 recalculating the values of the expressions stored the nodes having a dirty state.

16. The method of claim 15 wherein recalculating the values of the expressions is

performed automatically after completion of propagating the dirty state to each of the

nodes in the dependency graph.

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17. The method of claim 10 wherein:

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the dependency graph includes a plurality of expression nodes mapped in network

wherein the most-dependent expression node in the network has no
dependent expression nodes and the least-dependent expression node

depends directly on a scalar property; and

recalculating the values of expressions stored in nodes having a dirty state

includes (a) executing the expression corresponding to each of the
expression nodes in the network beginning with the least-dependent node
and ending with the most-dependent node, and (b) assigning the value of
each executed expression to the dynamic property corresponding to that
executed expression.

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18. The method of claim 17 wherein the HTML code generates a user interface upon
execution and at the property declared by the expression corresponding to the child node
defines as least a portion of the user interface, the method further comprising updating the
user interface upon assigning the value to the property declared by the expression
corresponding to the child node.

19. A computer for determining and outputting dynamic properties in HTML code received from a computer network, the computer comprising:

a processor;

a peripheral in data communication with the processor;

5 memory in data communication with the processor, the memory storing a browser for execution by the processor, the browser including code programmed to:

- (a) analyze the HTML code to identify scalar properties and expressions, each expression defining the value of a dynamic property and being a function of at least one scalar property;
- (b) map a dependent/dependency relationship between the expressions and the scalar properties, wherein each expression depends from at least one scalar property; and
- (b) upon notification of a change in value of the scalar property, execute each expression that depends on the scalar property having a changed value.

20. The computer of claim 19 wherein:

the scalar properties and the expressions are mapped into a dependency graph and
the browser is further programmed to assign a dirty state to each scalar
property upon notification of a change in the scalar property's value, and
5 propagate the dirty state from the scalar property to each expression that is
dependent on the dirty scalar property; and
the browser code programmed to execute each expression is further programmed
to execute only those expressions having a dirty state.

10 21. The computer of claim 20 wherein the browser code programmed to execute each
expression is further programmed to execute each expression in sequential order from a
least-dependent expression to a most-dependent expression, the least-dependent
expression depending directly on a scalar property and the most-dependent expression
having no dependent expressions.

15 22. The computer of claim 20 wherein the computer further includes an input for
receiving a signal, and the browser further includes code programmed to notice when a
signal received by the input changes the value of a scalar property, and in response
thereto automatically execute each expression that depends on the scalar property having
a value changed by the input signal.

20 23. The computer of claim 19 wherein the peripheral is a computer monitor and the
browser is further includes code programmed to display an HTML document having
dynamic properties on the computer monitor.

24. A browser for executing HTML code received from a computer network having a computer, the browser comprising:

code programmed to analyze HTML code and identify scalar properties and expressions, each expression defining the value of a dynamic property and being a function of the scalar property;

code programmed to map a dependent/dependency relationship between the expression and the scalar property; and

code programmed to notice a change in a value of the scalar property and to execute the expression in response to the change in value of the scalar property.

25. Apparatus for determining and processing dynamic properties of a document in HTML code received at a client computing system in a network of server and client computing systems, said apparatus operating in a browser at a client station, said apparatus comprising:

- 5 an expression engine identifying expressions and scalar properties received at the browser, each expression for a document defining the value of a dynamic property and being a function of at least one scalar property;
- a recalc engine mapping a dependent/dependency relationship between the expressions and the scalar properties, wherein each expression depends
- 10 from at least one scalar property;
- the recalc engine upon notification of a change in value of the scalar property executing each expression that depends on the scalar property having a changed value; and
- 15 a script engine responsive to the recalc engine and generating a display of the document in accordance with the dynamic property.

26. The apparatus of claim 25 wherein the recalc engine comprises:

a map module mapping the scalar properties and the expressions into a
dependency graph; and

a propagate module assigning a dirty state to a scalar property upon notification of
a change in the scalar property's value, and propagating the dirty state
from the scalar property to each expression that is dependent on the dirty
scalar property; and

an execute module executing each expression having a dirty state to provide the
dynamic property from the expression.

27. The apparatus of claim 26 wherein the execute module executes each expression in
sequential order from a least-dependent expression to a most-dependent expression, the
least-dependent expression depending directly on a scalar property and the most-
dependent expression having no dependent expressions.

28. The apparatus of claim 26 further comprises:

an input for receiving a signal;

notice module detecting when a signal received by the input changes the value of
a scalar property, and generating a changed property notification; and

the execute module in response to the changed property notification executes each
expression that depends on the scalar property having a value changed by
the input signal.

29. A computer data signal embodied in a carrier wave readable by a computing system and encoding a computer program of instructions for executing a computer process using expressions to establish a relationship between properties of a document generated by HTML code that is executable by a browser, the properties including constant properties and dynamic properties, said computer process comprising:

providing a value of one or more scalar properties, wherein the value of the scalar properties is not a function of another property;

creating one or more expressions, each expression declaring a value of a dynamic property, each dynamic property being a function of another property; and

generating a dependency graph, the dependency graph having a plurality of nodes, including at least one expression node and one leaf node, each expression node corresponding to an expression and each leaf node corresponding to a value of a scalar property, the dependency graph mapping the relationship between the properties.

30. The propagated signal of claim 29 wherein the nodes have a dependent/dependency relationship to one another and each node has either a dirty state or a clean state, and the computer process further comprises:

when the value for one of the properties changes, changing the state of the node corresponding to the changed property to dirty;

propagating the dirty state to each of the nodes in the dependency graph that are dependent on the node corresponding to the changed property; and

recalculating the values of the expressions stored in nodes having a dirty state.

31. The propagated signal of claim 30 wherein the act of recalculating the values of the expressions is performed automatically after completion of the act of propagating the dirty state to each of the nodes in the dependency graph.

32. The propagated signal of claim 30 wherein the dependency graph includes a plurality
5 of expression nodes mapped in network wherein the most-dependent expression node in the network has no dependent expression nodes and the least-dependent expression node depends directly on a scalar property; and the act of recalculating comprises:

executing the expression corresponding to each of the expression nodes in the
network beginning with the least-dependent node and ending with the
most-dependent node; and
10 assigning the value of each executed expression to the dynamic property
corresponding to that executed expression.

33. The propagated signal of claim 32 wherein the HTML code generates a user interface
upon execution and at the dynamic property declared by the expression defines at least a
15 portion of the user interface, and the computer process further comprises: updating the
user interface upon assigning the value to the dynamic property.